Derivation of Water Quality-Based
Effluent Limitations

      To support the implementation of EPA's national policy for controlling the discharge of toxicants, EPA developed the "*Technical Support Document for Water Quality-Based Toxics Control*" (EPA/505/2-90-001, March 1991). The TSD provides the procedures that EPA follows to develop water quality-based effluent limits. The purpose of a permit limit is to specify an upper bound of acceptable effluent quality that will result in the effluent meeting the wasteload allocation (WLA) under normal operating conditions virtually all the time. As discussed in the "*NPDES Permit Writers' Manual*" (EPA-833-B-96-003), it is not possible to guarantee through permit limits that a WLA will never be exceeded. However, using recommended permit limit derivation procedures, it is possible to account for extreme values and establish low probabilities of exceedance of the WLA in conformance with the duration and frequency requirements of water quality standards.

      Given the variability of effluents and that permit limits are developed based on low probability of exceedance, permit limits need to consider effluent variability and ensure that the requisite loading from the WLA is not exceeded under normal conditions. As a result, limits must force treatment plant performance levels that, after considering acceptable effluent variability, will only have a low statistical probability of exceeding the WLA and will achieve the desired loadings. The following is a summary of the procedures recommended in the TSD in deriving water quality-based effluent limitations for toxicants. This procedure translates water quality criteria for lead to effluent limits.

Step 1- Determine the WLA

      Because reasonable potential was demonstrated only during the winter period of October 1 - March 31, limits were calculated for that period. The current permit includes limits for both copper and lead for both summer and winter. The draft permit modification proposes to remove all the metals limits except for lead during the winter period.

      The acute and chronic aquatic life criteria are converted to acute and chronic waste load allocations (WLA_{acute} or $WLA_{chronic}$) for the receiving waters based on the following mass balance equation:

TABLE 1	Mass Balance Equation
$Q_dC_d = Q_eC_e + Q_uC_u$	
where,	
Q_d =	downstream flow = $Q_u + Q_e$
C_d =	aquatic life criteria that cannot be exceeded downstream (expressed as total recoverable)
Q_e =	effluent flow
C_e =	concentration of pollutant in effluent = WLA$_{acute}$ or WLA$_{chronic}$ (expressed as total recoverable)
Q_u =	upstream flow
C_u =	upstream background concentration of pollutant (expressed as total recoverable)

Rearranging the steady-state mass balance equation to determine the effluent concentration (C_e) or the wasteload allocation (WLA) results in the following:

$$C_e = WLA = \frac{Q_dC_d - Q_uC_u}{Q_e}$$

When a mixing zone is allowed, this equation becomes:

$$C_e = WLA = \frac{C_d(Q_u \times MF) + C_dQ_e}{Q_e} - \frac{Q_uC_u(MF)}{Q_e}$$

All of the factors in the above equation were defined in Appendix A. Wasteload allocations are calculated for both the acute and chronic criteria.

Since Idaho water quality criteria for metals are expressed as dissolved, and permit limits must be expressed as total recoverable, the criteria and background concentrations must be converted to total recoverable[1]. This is accomplished by applying either site-specific translators developed by the permittee or State, or by applying the conversion factors from dissolved to total recoverable as default translators. The City of Boise developed a site specific translator for lead as shown in the following table. As discussed in Appendix A, a site -specific translator was developed for lead.

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[1]   **40 CFR § 122.45(c).**

TABLE 2	Translator, Converted Criterion, and Background Concentration			
Parameter	Site-Specific Translator developed based on City of Boise Data[1]	Aquatic Life Criteria[2] Cd, µg/L		Upstream Concentration Cu, µg/L
		October - March		
		Acute	Chronic	
Lead	0.804	138	5.35	0
1 City of Boise permit modification submittal July 25, 2002. 2 Expressed as total recoverable: Cd(diss)/translator				

For the period October 1 - March 31:

Lead WLA$_{acute}$ = $\dfrac{(138 \times 69.1 \times 0.25) + (138 \times 37.1) - (0 \times 0.25 \times 69.1)}{37.1}$

= 202 µg/L

Lead WLA$_{chronic}$ = $\dfrac{(5.35 \times 74.8 \times 0.25) + (5.35 \times 37.1) - (0 \times 0.25 \times 74.8)}{37.1}$

= 8.05 µg/L

Step 2 - Determine the LTA

The acute and chronic WLAs are then converted to Long Term Average concentrations (LTA$_a$ and LTA$_c$) using the following equations:

$$LTA_{acute} = WLA_{acute} \times e^{[0.5F^2 - zF]}$$

where,

CV = coefficient of variation = standard deviation/mean
$\quad$ CV$_{lead}$ = 0.76^2
F^2 = ln(CV^2 + 1); F$^2_{Pb}$ = 0.455 F$_{Pb}$ = 0.675
z = 2.326 for 99th percentile probability basis, per the TSD

LTA$_{acute}$ = 202 X e$^{(0.5(0.455) - (2.326)(.675))}$

$$LTA_{chronic} = WLA_{chronic} \times e^{[0.5F^2 - zF]}$$

where,

$CV_{lead} = 0.76$

$F^2 = \ln(CV^2/4 + 1);\ F^2_{Pb} = 0.134\ F_{Pb} = 0.367$

$z = 2.326$ for 99th percentile probability basis

$$LTA_{chronic} = 8.05\ X\ e^{((0.5)(0.134)-((2.326)(0.367))}$$

Calculate the LTA_{acute} and the $LTA_{chronic}$:

Lead $LTA_{acute} = 52.8\ \mu g/L$

Lead $LTA_{chronic} = 3.63\ \mu g/L$

Step 3 - Determine the Limiting LTA

To protect a waterbody from both acute and chronic effects, the more limiting of the calculated LTA_{acute} and $LTA_{chronic}$ is used to derive the effluent limitations. For lead, the $LTA_{chronic}$ value was less than the LTA_{acute} value.

Step 4 - Determine the Permit Limits

The MDL and the AML would be calculated as follows[3]:

$$MDL = LTA_{limiting}\ X\ e^{[zF-0.5F^2]}$$

where,

F^2 = $\ln(CV^2 + 1)$

z =   2.326 for 99th percentile probability basis

CV =   coefficient of variation

$$AML = LTA_{limiting}\ X\ e^{[zF-0.5F^2]}$$

where,

F^2 = $\ln(CV^2/n + 1)$

z =   1.645 for 95th percentile probability basis

CV =   coefficient of variation = standard deviation/mean

n =   number of sampling events required per month for metals = 1

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[3]   **The TSD recommends using the 95th percentile for the Average Monthly Limit (AML) and the 99th percentile for the Maximum Daily Limit (MDL).**

n $\quad=\quad$ 4 for calculations[4]

The following table lists the effluent limitations for Outfall 001, for the period October 1 - March 31:

TABLE 4	Proposed Effluent Limitations					
Parameter	CV	LTA	$e^{[zF-0.5F^2]}$ (for MDL)	$e^{[zF-0.5F^2]}$ (for AML)	MDL µg/L	AML µg/L
Lead	0.76	3.63	3.83	1.71	13.9	6.21

The current permit limits, scheduled to become effective February 12, 2003 (lead) and November 2, 2004 (copper) are shown below.

TABLE 5	Current Effluent Limitations			
Copper[1], : g/L	4/1 - 9/30	9.9	---	20.0
	10/1 - 3/31	10.4		21.0
Lead[2], : g/L	4/1 - 9/30	2.52	—	5.50
	10/1 - 3/31	2.84		6.18
[1]	**These limits become effective November 2, 2004.**			
[2]	**These limits become effective February 12, 2003.**			

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[4] **The TSD recommends that where the sample frequency is monthly or less, that n be set equal to 4.**